

NAME: Jinyi Xia
 STUDENT ID: 2021212057
 CLASS NUMBER: 2021211802

ASSIGNMENT 4

The grammar G is given as follows:

- (1) $S \rightarrow \mathbf{a}B$,
- (2) $B \rightarrow S + B$,
- (3) $B \rightarrow \epsilon$.

Consider the augmented grammar G' :

- $S' \rightarrow S$,
- $S \rightarrow \mathbf{a}B$,
- $B \rightarrow S + B \mid \epsilon$.

1 Exercise 1

- Calculate the FIRST and FOLLOW sets for G .

$$\begin{aligned}\text{FIRST}(S) &= \{\mathbf{a}\}, \\ \text{FIRST}(B) &= \{\mathbf{a}, \epsilon\}, \\ \text{FOLLOW}(S) &= \{+, \$\}, \\ \text{FOLLOW}(B) &= \{+, \$\}.\end{aligned}$$

Construct the collection of sets of LR(0) items for G' .

$I_0:$ $S' \rightarrow \cdot S$ $S \rightarrow \cdot \mathbf{a}B$	$I_2:$ $S \rightarrow \mathbf{a} \cdot B$ $B \rightarrow \cdot S + B$ $B \rightarrow \cdot$ $S \rightarrow \cdot \mathbf{a}B$	$I_5:$ $B \rightarrow S + \cdot B$ $B \rightarrow \cdot S + B$ $B \rightarrow \cdot$ $S \rightarrow \cdot \mathbf{a}B$
$I_1:$ $S' \rightarrow S \cdot$	$I_3:$ $S \rightarrow \mathbf{a}B \cdot$	$I_6:$ $B \rightarrow S + B \cdot$
	$I_4:$ $B \rightarrow S \cdot + B$	

Construct the SLR(1) parsing table for G' .

STATE	ACTION			GOTO	
	a	+	\$	S	B
0	s2			1	
1			acc		
2	s2	r3	r3	4	3
3		r1	r1		
4		s5			
5	s2	r3	r3	4	6
6		r2	r2		

2. Yes, it is.

3. Yes, it can.

	STACK	SYMBOLS	INPUT	ACTION
(1)	0		aaaa +++ \$	shift
(2)	0 2	a	aaa +++ \$	shift
(3)	0 2 2	aa	aa +++ \$	shift
(4)	0 2 2 2	aaa	a +++ \$	shift
(5)	0 2 2 2 2	aaaa	+++ \$	reduce by $B \rightarrow \epsilon$
(6)	0 2 2 2 2 3	aaaaB	+++ \$	reduce by $S \rightarrow \mathbf{a}B$
(7)	0 2 2 2 4	aaaS	+++ \$	shift
(8)	0 2 2 2 4 5	aaaS+	++ \$	reduce by $B \rightarrow \epsilon$
(9)	0 2 2 2 4 5 6	aaaS+B	++ \$	reduce by $B \rightarrow S+B$
(10)	0 2 2 2 3	aaaB	++ \$	reduce by $S \rightarrow \mathbf{a}B$
(11)	0 2 2 4	aaS	++ \$	shift
(12)	0 2 2 4 5	aaS+	+ \$	reduce by $B \rightarrow \epsilon$
(13)	0 2 2 4 5 6	aaS+B	+ \$	reduce by $B \rightarrow S+B$
(14)	0 2 2 3	aaB	+ \$	reduce by $S \rightarrow \mathbf{a}B$
(15)	0 2 4	aS	+ \$	shift
(16)	0 2 4 5	aS+	\$	reduce by $B \rightarrow \epsilon$
(17)	0 2 4 5 6	aS+B	\$	reduce by $B \rightarrow S+B$
(18)	0 2 3	aB	\$	reduce by $S \rightarrow \mathbf{a}B$
(19)	0 1	S	\$	accept

2 Exercise 2

1. Construct the collection of sets of LR(1) items for G' .

$I_0:$	$I_2:$	$I_3:$	$I_5:$
$S' \rightarrow \cdot S, \quad \$$		$S \rightarrow \mathbf{a}B \cdot, \quad \$$	
$S \rightarrow \cdot \mathbf{a}B, \quad \$$			
	$S \rightarrow \mathbf{a} \cdot B, \quad \$$		$B \rightarrow S + \cdot B, \quad \$$
	$B \rightarrow \cdot S + B, \quad \$$		$B \rightarrow \cdot S + B, \quad \$$
$I_1:$	$B \rightarrow \cdot, \quad \$$	$I_4:$	$B \rightarrow \cdot, \quad \$$
$S' \rightarrow S \cdot, \quad \$$	$S \rightarrow \cdot \mathbf{a}B, \quad +$	$B \rightarrow S \cdot + B, \quad \$$	$S \rightarrow \cdot \mathbf{a}B, \quad +$

$I_6:$	$B \rightarrow S + B \cdot, \$$	$I_8:$	$S \rightarrow \mathbf{a} B \cdot, +$	$I_{10}:$	$B \rightarrow S + \cdot B, +$	$B \rightarrow \cdot S + B, +$	$B \rightarrow \cdot, +$	$S \rightarrow \cdot \mathbf{a} B, +$	$I_{11}:$	$B \rightarrow S + B \cdot, +$
$I_7:$	$S \rightarrow \mathbf{a} \cdot B, +$	$I_9:$	$B \rightarrow S \cdot + B, +$							
	$B \rightarrow \cdot S + B, +$									
	$B \rightarrow \cdot, +$									
	$S \rightarrow \cdot \mathbf{a} B, +$									

Construct the canonical LR(1) parsing table for G' .

STATE	ACTION			GOTO	
	a	+	\$	S	B
0	s2			1	
1			acc		
2	s7		r3	4	3
3			r1		
4		s5			
5	s7		r3	4	6
6			r2		
7	s7	r3		9	8
8		r1			
9		s10			
10	s7	r3		9	11
11		r2			

2. Yes, it can.

	STACK	SYMBOLS	INPUT	ACTION
(1)	0		aaaa +++ $\$$	shift
(2)	0 2	a	aaa +++ $\$$	shift
(3)	0 2 7	aa	aa +++ $\$$	shift
(4)	0 2 7 7	aaa	a +++ $\$$	shift
(5)	0 2 7 7 7	aaaa	+++ $\$$	reduce by $B \rightarrow \epsilon$
(6)	0 2 7 7 7 8	aaaaB	+++ $\$$	reduce by $S \rightarrow \mathbf{a}B$
(7)	0 2 7 7 9	aaaS	+++ $\$$	shift
(8)	0 2 7 7 9 10	aaaS+	++ $\$$	reduce by $B \rightarrow \epsilon$
(9)	0 2 7 7 9 10 11	aaaS+B	++ $\$$	reduce by $B \rightarrow S+B$
(10)	0 2 7 7 8	aaaB	++ $\$$	reduce by $S \rightarrow \mathbf{a}B$
(11)	0 2 7 9	aaS	++ $\$$	shift
(12)	0 2 7 9 10	aaS+	+ $\$$	reduce by $B \rightarrow \epsilon$
(13)	0 2 7 9 10 11	aaS+B	+ $\$$	reduce by $B \rightarrow S+B$
(14)	0 2 7 8	aaB	+ $\$$	reduce by $S \rightarrow \mathbf{a}B$
(15)	0 2 9	aS	+ $\$$	shift
(16)	0 2 9 10	aS+	$\$$	reduce by $B \rightarrow \epsilon$

(continued)

	STACK	SYMBOLS	INPUT	ACTION
(17)	0 2 9 10 11	$\mathbf{a}S + B$	\$	reduce by $B \rightarrow S + B$
(18)	0 2 8	$\mathbf{a}B$	\$	reduce by $S \rightarrow \mathbf{a}B$
(19)	0 1	S	\$	accept

3 Exercise 3

1. There are 5 pairs of sets of items that can be merged.

I_2 and I_7 are replaced by their union:

$$\begin{aligned}
 I_{2,7} : \quad & S \rightarrow \mathbf{a} \cdot B, \quad +/\$ \\
 & B \rightarrow \cdot S + B, \quad +/\$ \\
 & B \rightarrow \cdot, \quad +/\$ \\
 & S \rightarrow \cdot \mathbf{a} B, \quad +/\$
 \end{aligned}$$

I_3 and I_8 are replaced by their union:

$$I_{3,8} : S \rightarrow \mathbf{a} B \cdot, \quad +/\$$$

I_4 and I_9 are replaced by their union:

$$I_{4,9} : B \rightarrow S \cdot + B, \quad +/\$$$

I_5 and I_{10} are replaced by their union:

$$\begin{aligned}
 I_{5,10} : \quad & B \rightarrow S + \cdot B, \quad +/\$ \\
 & B \rightarrow \cdot S + B, \quad +/\$ \\
 & B \rightarrow \cdot, \quad +/\$ \\
 & S \rightarrow \cdot \mathbf{a} B, \quad +/\$
 \end{aligned}$$

I_6 and I_{11} are replaced by their union:

$$I_{6,11} : B \rightarrow S + B \cdot, \quad +/\$$$

The LALR(1) parsing table for G' is as follows.

STATE	ACTION			GOTO	
	\mathbf{a}	$+$	$\$$	S	B
0	s2,7			1	
1			acc		
2,7	s2,7	r3	r3	4,9	3,8
3,8		r1	r1		
4,9		s5,10			
5,10	s2,7	r3	r3	4,9	6,11
6,11		r2	r2		

2. Yes, it can.

	STACK	SYMBOLS	INPUT	ACTION
(1)	0		aaaa + + + \$	shift
(2)	0 2,7	a	aaa + + + \$	shift
(3)	0 2,7 2,7	aa	aa + + + \$	shift
(4)	0 2,7 2,7 2,7	aaa	a + + + \$	shift
(5)	0 2,7 2,7 2,7 2,7	aaaa	+ + + \$	reduce by $B \rightarrow \epsilon$
(6)	0 2,7 2,7 2,7 2,7 3,8	aaaaB	+ + + \$	reduce by $S \rightarrow \mathbf{aB}$
(7)	0 2,7 2,7 2,7 4,9	aaaS	+ + + \$	shift
(8)	0 2,7 2,7 2,7 4,9 5,10	aaaS+	+ + \$	reduce by $B \rightarrow \epsilon$
(9)	0 2,7 2,7 2,7 4,9 5,10 6,11	aaaS + B	+ + \$	reduce by $B \rightarrow S + B$
(10)	0 2,7 2,7 2,7 3,8	aaaB	+ + \$	reduce by $S \rightarrow \mathbf{aB}$
(11)	0 2,7 2,7 4,9	aaS	+ + \$	shift
(12)	0 2,7 2,7 4,9 5,10	aaS+	+ \$	reduce by $B \rightarrow \epsilon$
(13)	0 2,7 2,7 4,9 5,10 6,11	aaS + B	+ \$	reduce by $B \rightarrow S + B$
(14)	0 2,7 2,7 3,8	aaB	+ \$	reduce by $S \rightarrow \mathbf{aB}$
(15)	0 2,7 4,9	aS	+ \$	shift
(16)	0 2,7 4,9 5,10	aS+	\$	reduce by $B \rightarrow \epsilon$
(17)	0 2,7 4,9 5,10 6,11	aS + B	\$	reduce by $B \rightarrow S + B$
(18)	0 2,7 3,8	aB	\$	reduce by $S \rightarrow \mathbf{aB}$
(19)	0 1	S	\$	accept